Comparison of fracture resistance in post restorations in primary maxillary incisors

ABSTRACT

Aim This in vitro study aimed to test the fracture resistance of 4 different posts used in the restoration of severely decayed primary incisors.

Materials and methods Fifty primary incisors were selected for this study and sectioned 1 mm above the CEJ. After filing and irrigation of the root canal space, the canals were obturated with Metapex and 3 mm of post space was prepared inside the canals. Intact glass fiber posts, split-ended glass fiber posts, composite resin posts, and orthodontic γ “gamma” wire posts were used as intracanal posts and the final composite resin restoration was placed using a paediatric strip crown. After thermocycling of the specimens, the fracture resistance was measured using a universal testing machine.

Results The mean fracture resistance of split-ended glass fiber posts was higher than the other groups, however, there was no significant difference between any of the groups (P>0.05).

Conclusion Split-ended glass fiber posts seem to be a more appropriate option for full coverage restorations in primary incisors.

Keywords Fracture resistance; Intracanal posts; Primary incisors; Restorative dentistry.

Introduction

Early childhood caries is a specific form of severe dental caries that affects infants and children [Warren et al., 2000]. It is defined as the presence of more than one decayed (non-cavitated or cavitated lesion), missing (due to decay) or filled tooth surface in any primary tooth in a child 71 months or younger [Casamassimo et al., 2013a]. Any sign of smooth surface caries in a child younger than 3 years is indicative of severe early childhood caries (SECC). Between the ages of 3 and 5 years, severe early childhood caries (SECC) is defined as one or more cavitated, missing (due to caries) or filled smooth surface in primary maxillary anterior teeth or dmfs score greater than 4 at age 3 years, greater than 5 at age 4 years, or greater than 6 at age 5 years [Casamassimo et al., 2013a].

SECC is a devastating condition for both the child undergoing dental treatment and the concerned parents [Gujar and Indushekar, 2010]. It is very difficult for paediatric dentists to restore severely decayed primary maxillary incisors with restorations that are durable, retentive and aesthetic [Casamassimo et al., 2013b]. Early loss of primary anterior teeth may result in reduced masticatory efficiency, loss of vertical dimension, development of parafunctional habits and psychological problems that can interfere with the personality and behaviour development of the child [Ngan and Fields, 1995; Motisuki et al., 2005]. Restorative treatment options mentioned in the literature include direct and indirect technique using prefabricated crowns, as well as biologic and resin composite restorations [Croll, 1990; Aron, 1995]. In cases where, due to severe caries, there is not enough tooth structure available to bond with composite resin, endodontic treatment and placement of intracanal posts or retainers becomes necessary prior to tooth restoration [Mendes et al., 2004]. Several types of posts are available for use in paediatric restorative dentistry including metal posts, composite posts and glass fiber posts. Glass fiber posts offer excellent features including biocompatibility, fatigue and corrosion resistance, and have mechanical properties similar to dentin [Mitsui et al., 2004]. They need to be cut to the appropriate length before using them in the primary root canals. Shortening the glass fiber posts could disrupt the integrity of posts and make it split-ended (Fig. 1). Split-ended posts have some thin fibers at their end which could possibly increase the retention of composite resin to the tooth structure compared to the intact fibers.

The purpose of this study was to evaluate fracture resistance in vitro of 4 different types of intracanal posts (intact glass fiber post, split-ended glass fiber post, “gamma” wire posts, composite resin posts) used in full coverage restorations of severely decayed primary maxillary incisors.
Preparation of the specimens
Fifty primary maxillary incisors were selected for this study, all had been extracted in the previous 6 months. The teeth were thoroughly cleaned and debrided immediately after extraction and stored in 0.5% Chloramine T for 7 days, then in distilled water at room temperature until they were used. The inclusion criteria were as follows: cervical third of crowns should be intact, no pathologic resorption of root should be evident macroscopically or radiographically, no previous root canal treatment should have been performed on these roots. The teeth were cross-sectioned 1 mm above the cement-enamel junction by 008 diamond fissure bur (Teezkavan, Tehran, Iran). Root canals were filed and irrigated with 0.9% normal saline solution and then they were dried using No. 40 paper points (Ariadent, Tehran, Iran). Metapex (Metabiomed, Chungbuk, Korea) was injected into the canal space a little short of the canal orifice and then glass ionomer lining cement (GC Fuji, Tokyo, Japan) was inserted into the canal space up to 3 mm inside the root canals. Post space was prepared using 008 diamond bur (Teezkavan, Tehran, Iran) by removing excess glass ionomer cement to 3 mm inside the root canals. Teeth were divided into 5 groups as follows.

- **Group 1**, Composite resin posts using Filtek Z350 (3M ESPE, St Paul, USA).
- **Group 2**, γ “gamma” wire posts (American tooth industries, Oxnard, CA, USA).
- **Group 3**, Intact glass fiber post (Nordin, Montreux, Switzerland).
- **Group 4**, Split-ended glass fiber post (Nordin, Montreux, Switzerland).
- **Group 5**, No post as control group.

**Group 1**
The canal space and remaining tooth structure were etched using 35% phosphoric acid (3M ESPE, St Paul, USA) for 20 seconds and then washed with a compressed stream of air and water for 10 seconds. Then the surfaces were dried with gentle air stream to avoid desiccation of the surfaces; 2 layers of dentin bonding agent (Adper Single Bond, 3M ESPE, St Paul, USA) were used on the surfaces and gently air thinned for 5 seconds to evaporate solvents and light cured for 20 seconds with Elipar S10 curing light (3M ESPE, St Paul, USA). Flowable composite Filtek Z350 (3M ESPE, St Paul, USA) was injected into the canal space and on the cross-sectioned surface of root and cured for 40 seconds.

To assimilate the crown dimensions in all groups, we used the paediatric anterior strip crown size 1 for left central incisor (3M ESPE, St Paul, USA). The strip crowns were filled with flowable composite, put on the sectioned surfaces and light cured from buccal and palatal surfaces for 40 seconds. Finally the strip crowns were removed with the tip of an explorer and the composite excess, if any, was polished with an egg-shaped polishing bur (Teezkavan, Tehran, Iran).

**Group 2**
In the second group, 0.7 mm stainless steel orthodontic wire (American tooth industries, Oxnard, CA, USA) was used to form a γ shape (Fig. 2), in a way that the loop portion of the γ shaped wire was put inside the canal and the free end extended 3 mm out of the canal. The etching and bonding technique was the same as the first group. The flowable composite was then injected inside the canal space and the γ shaped wire was inserted in the canal. While holding the free end of wire with cotton forceps, the composite was cured for 40 seconds. The crown was also formed using the same strip crown as the first group.

**Group 3**
Intact Glass fiber posts (Nordin, Montreux, Switzerland), as shown in figure 3, were cut so as to obtain the length of 6 mm and then inserted inside the canal filled with flowable composite resin from the scissor cut end. Holding the fiber post with cotton pliers, the composite was then cured as other groups and the crown was formed with the same size strip crown as Group 1.

**Group 4**
The glass fiber post (Nordin, Montreux, Switzerland) was cut to obtain the length of 6 mm and then the cut end was flattened with a Howe angled orthodontic plier (Karl Schumacher, Southampton, PA, USA) as shown in figure 1. This created several thin fibers separated from the main one which we called a split-ended fiber. The fiber was inserted inside the canal space from the...
intact end to obtain 3 mm of its length outside the canal and then the composite was cured and the crown was formed with the same strip crown as the previous groups.

**Group 5**

In the fifth and last group, Metapex (Metabiomed, Chungbuk, Korea) was injected inside the canal and then the glass ionomer lining cement (GC Fuji, Tokyo, Japan) was inserted inside the canal to the same level of the canal’s orifice. The sectioned surface was etched, washed and bonded as in the other groups and after light curing the surface for 20 seconds, the strip crown was filled with composite resin, placed on the root surface and cured from both buccal and palatal surfaces separately for 40 seconds each surface.

**Fracture resistance measuring**

All the specimens were mounted in self-cured acryl orthoresin (Dentsply, Konstanz, Germany) within a cylindrical mold in a way that the crown portion, especially the composite-dentin interface area, remained out of acryl completely.

All the specimens were stored in distilled water at 37°C for 24 hours and then thermocycled 5000 times between water baths held at 5°C and 55°C with 60s of dwell time.

The fracture resistance was measured using Universal testing machine (Santam UTM, Tehran, Iran). The dislodging force was applied using 1000 Newton load cell, which exerted a load ranging from 0.1 gram to 10 kg. The values obtained at fracture were recorded in Newtons. The type of fracture was also recorded as either adhesive failure (which occurred at the interface of composite and tooth structure), cohesive failure (which occurred inside the composite restoration) or mixed failure (which was a combination of adhesive and cohesive failures). The type of fracture was determined visually where possible or by means of a stereomicroscope (Olympus, SZX 16, Tokyo, Japan).

**Statistical analysis**

The data was statistically analysed using one-way ANOVA and post-hoc Tukey HSD test. A P-value less than 0.05 was considered to be statistically significant.

**Results**

The mean fracture resistance values and standard deviations for different groups are shown numerically in Table 1. The lowest fracture resistance value was recorded for the control group with no post inside the canals. The highest mean fracture resistance value was recorded in the split-ended glass fiber post. The Tukey test analysis revealed no significant differences among any of the groups (P>0.05).

**Discussion**

Adhesive restorations on primary incisors are very challenging [Casamassimo et al., 2013c]. Composite restorations, extensively used nowadays, usually need sufficient healthy tooth structure to create micromechanical retention of the restoration, which is the primary mechanism of attachment [Roberson et al., 2006].

The use of intracanal posts in endodontically treated teeth improves the retention of definitive restorations [Grosso, 1987] and offers an aesthetic and functional treatment option in severely decayed primary anterior teeth [Gujar and Indushekar, 2010]. This form of reconstruction should provide adequate retention and appreciably withstand masticatory forces in function [Viera and Ribeiro, 2001]. Different kinds of posts have been used in paediatric dentistry such as orthodontic wire post [Mortada and King, 2004], short post with composite resin [Mendes et al., 2004], polyethylene ribbon posts [Viera and Ribeiro, 2001] and biological posts [Ramires-Romito et al., 2000]. Composite resin restorations, reinforced with mechanically retained orthodontic wires, were described in 2004 [Mortada and King, 2004]. In our experience, bending the orthodontic wire into a γ shape and inserting it into the 3 mm canal space can be somewhat difficult. Specifically, handling the delicate and small γ orthodontic wire and adapting it into the canal space requires great dexterity and may ultimately lead to radicular fracture as a result of excessive masticatory force [Viera and Ribeiro, 2001]. Another option could be the use of biologic posts made from extracted primary teeth [Ramires-Romito et al., 2000]. The disadvantage of this technique includes the need for a tooth bank and for parental and child consent by both donors and recipients of the tooth fragments [Ramires-Romito et al., 2000]. In addition, this technique does not comply with modern cross-infection control protocols [Motisuki et al., 2005].

Glass fiber posts are another option as intraradicular posts which are available in different diameters. This material permits the chemical and mechanical adhesion to the restorative materials resulting in durable restorations with good aesthetics [Motisuki et al., 2005]. Sharaf reported that restorations done

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean (N)</th>
<th>Standard Error</th>
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<tbody>
<tr>
<td>γ wire post</td>
<td>219.661</td>
<td>44.505</td>
</tr>
<tr>
<td>Intact glass fiber post</td>
<td>203.937</td>
<td>40.918</td>
</tr>
<tr>
<td>Split-ended glass fiber post</td>
<td>363.201</td>
<td>71.761</td>
</tr>
<tr>
<td>Composite resin post</td>
<td>268.194</td>
<td>42.612</td>
</tr>
<tr>
<td>Control with no post</td>
<td>191.95</td>
<td>47.657</td>
</tr>
</tbody>
</table>

**TABLE 1 Fracture resistance and standard error values for different types of post.**
TABLE 2 Different types of failures in each group.

<table>
<thead>
<tr>
<th>Group</th>
<th>Adhesive Failure</th>
<th>Cohesive Failure</th>
<th>Mixed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

on primary incisors remained intact after one year follow-up [Sharaf, 2002]. Laboratory studies have also demonstrated that this technique significantly improved the fracture resistance of teeth [Sharaf, 2002]. Glass fiber posts are too long for use inside the 3 mm canal space of primary teeth; thus, in order to obtain the proper length of 6 mm, the fibers were cut using a scissor. Utilizing this technique, we noticed that some small fibers will come out of the original glass fiber and stay shredded. We decided to evaluate these small fiber ends to see if they might increase the fracture resistance of final restoration, as compared to the other post options and control groups.

The highest fracture resistance was observed with the split-end glass fiber post, followed by composite resin post, intact glass fiber post, γ shaped post and finally the control group. It seems that although the difference was statistically insignificant between the groups, split ended glass fiber posts could increase the fracture resistance of the completed restoration. Regarding composite resin posts, there is a risk of a loss of retention owing to polymerisation shrinkage [Judd et al., 1990]. Gujjar and Indushekar [2010] obtained better results with glass fiber posts followed by γ wire posts and composite posts, but their study evaluated tensile strength of the restorations; this differed from our study, which compared fracture resistance of the restorations.

We had some adhesive and cohesive failures in all test groups (Table 2); but in the control group, all specimens showed adhesive failure. This clearly indicates the rationality and increased chance of a positive clinical outcome of restoring severely compromised primary maxillary incisors with an intracanal post.

In conclusion, it seems that split-ended glass fiber posts are a more suitable option for full-coverage restoration of primary maxillary incisors and also intracanal posts may increase the likelihood of a positive treatment outcome when restoring a maxillary primary incisor with a full-coverage restoration.

Acknowledgment

The authors wish to thank the Biomaterial Department of the Faculty of Dentistry, Tehran University of Medical Science for their support with the experiments.

References